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UNIVERSITY OF MAINE

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RECENT ADVANCES IN SPRAY PRACTICES FOR MAINE APPLE ORCHARDS

Modern methods and up-to-date equipment help Maine growers to produce highest quality apples.

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RECENT ADVANCES IN SPRAY PRACTICES FOR MAINE APPLE ORCHARDS

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The production of apples has become a complex, technical, and highly competitive industry. To meet the situation the successful apple grower attempts to keep up-to-date in his methods and equipment.

This bulletin is written in an effort to discuss the most recent information on orchard spray practices for the Maine apple grower. The information is based primarily upon the results of experimental work conducted by the Maine Agricultural Experiment Station, supplemented by observations of practices followed by progressive orchardists in the several sections of the State. The discussion is presented in a condensed and rather informal way. Detailed data upon which the conclusions are based have been presented in reports and technical papers issued during recent years, or soon to be published by the Station.

The recommendations have been carefully considered and are intended to be fairly conservative practices generally applicable to most Maine orchards.

NEW SPRAY EQUIPMENT

In the past few seasons various new kinds of spray and dust machinery have appeared in Maine orchards. Several were demonstrated at the Pomological Society Field Day on August 20, 1947, at Highmoor Farm. Several of these new kinds of machinery are illustrated in Fig. 1. Much research and considerable field experience will be necessary to evaluate properly these new methods of applying materials to orchard trees.

Commercial orchardists not interested at the moment in spray booms would do well to consider the improvements that can be made on present equipment by getting the spray gun higher

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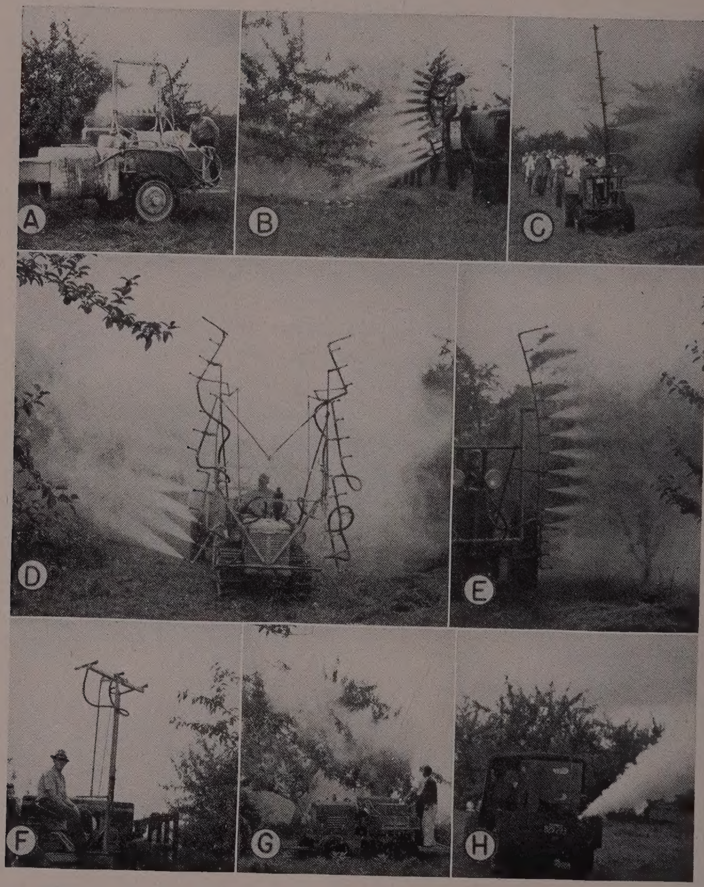

FIG. 1. Several kinds of spray and dust equipment demonstrated at Highmoor Farm during the Field Day of the Maine State Pomological Society, August 20, 1947.

A. The Automatic Spraying Unit of the Grand Traverse Orchard Supply Company. B. The Hardie Multi-Nozzle Spray Boom. C. The Bean Spray Mast. D. The Highmoor Farm Sectional Spray Boom. E. The Highmoor Farm Multiple-Nozzle Spray Boom. F. The Ricker-Hill-Orchard Spray Rig. G. The Niagara Liqui-Duster. H. The Todd Fog Applicator.

in the air. The Ricker-Hill-Orchard Spray Rig as illustrated in Fig. 1, F., is a new improvement of the basic idea of the Cheney Spray Rig developed about 1928 by I. H. Cheney, formerly Superintendent at Highmoor Farm. Some 20 years' experience at Highmoor Farm indicates that better scab control results when the spray nozzles are moved up closer to the top of the tree. It is obvious that there is also considerably less strain on the operator when he is on a movable seat made in such a way that freedom of movement is possible. With the Ricker-Hill-Orchard Spray Rig, the operator can spray in any direction simply by turning his body. In normal use this outfit is mounted on top of the spray tank in such a way that the operator is seated only a short distance from the top of the tank while the spray nozzles are considerably higher. This gives the advantage of spraying down into the tree, while not having difficulty in adequately spraying the tops or upright and outward growing branches.

Various modifications of the Cheney Spray Rig have appeared, depending on the ingenuity of the individual orchardist. Wilson Morse, of East Waterford, has for years been spraying with a one-man outfit, somewhat similar to that shown in Fig. 3, F., operated from the tractor seat by means of levers. The saving in labor is obvious—the spray application is made by one man instead of a crew consisting of a tractor driver and a spray man.

The most recent development in apple tree spraying equipment has been the use of spray booms. Two types of booms developed at Highmoor Farm are described in detail and directions given for their construction in Maine Agricultural Experiment Station Bulletin 458. The Highmoor Farm spray booms have demonstrated considerable advantage over the hand-operated brooms and guns formerly used. In the 1947 tests the spray booms were used at Highmoor Farm from the petal-fall spray to the end of the season. Satisfactory control of scab was obtained with both types of booms. For larger bearing trees the Sectional Boom as illustrated in Fig. 1, D., proved to be the more satisfactory. The top section of this boom is moved, when necessary, by means of a lever operated by the tractor driver to obtain better coverage of the tops of trees and of outward and upright growing branches. The Multiple Nozzle Boom, illustrated in Fig. 1, E., proved very satisfactory on smaller trees and in orchard blocks planted to trees of the same age where height

growth was about uniform. It was found that the use of these booms resulted in a saving of about 30 per cent in spray material, and about 45 per cent in the time required to spray a given orchard block. There is also a saving in labor, since only one man drives the tractor and operates the spray outfit. It is doubtful if any one kind of spray boom will prove universally satisfactory in Maine orchards, but the benefits of spraying with booms rather than with hand-operated spray guns is so obvious that the future holds much promise for improvements in methods of spraying. The task of spraying apple trees is tedious and costly, and any improvement that can be made should be welcome.

NEW FUNGICIDES

There has been considerable interest recently in testing new organic fungicides. Although wettable sulphur is still one of the best fungicides for apple scab control, it has certain disadvantages that possibly can be avoided in another kind of material. Wettable sulphur is not as effective under severe environmental conditions as are some other materials, such as lime sulphur, and even wettable sulphur may cause spray injury to leaves and fruit under some

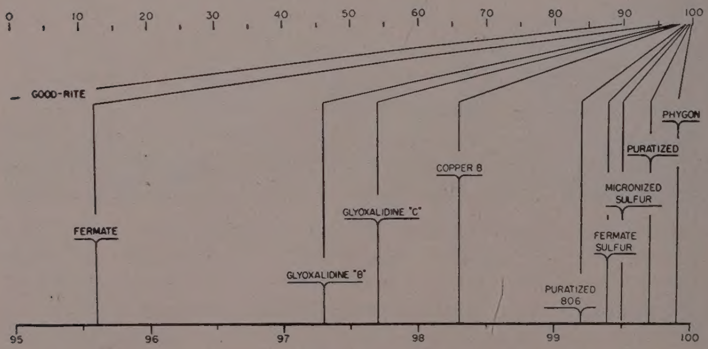

FIG. 2. The effectiveness of various apple fungicides shown as percentage of fruit scab control. As shown on the upper line, all the fungicides except Good-rite gave satisfactory control. On the lower line the scale is magnified in order to differentiate more clearly the relative position of each fungicide.

conditions. Heavy applications of sulphur to apple trees also seem to have a harmful effect upon the natural enemies that aid greatly in the control of European red mite and oyster-shell scale. The ideal fungicide for apples would be one that gives satisfactory control of scab, permits good growth and yield of trees, does not cause spray injury, is tolerant of environmental conditions, is low in cost, is easily mixed in the spray tank, and is compatible with other spray materials. According to this definition, the ideal is yet to be found, but there are some new materials that appear promising. The outstanding features of some of the new fungicides tested at Highmoor Farm during the past few years are given here. Fig. 2 shows the percentage control of fruit scab obtained at Highmoor Farm in 1947 when various fungicides were compared.

PURATIZED AGRICULTURAL SPRAY

This material is one of the most promising of the new organic fungicides. It was first used in Maine in 1944 and showed considerable promise from the beginning. Since this material contains mercury, it is not recommended for use after petal-fall application, because of the danger of harmful residue on the fruit. In the tests discussed here, Puratized was used up to and including the petal-fall spray, followed by wettable sulphur in the cover sprays. When first tried, in 1944, the active ingredient, phenyl mercuri triethanol ammonium lactate, was used at a concentration of about 1 : 7000 and scab control was excellent; fruit scab being 1.1 per cent for Puratized as compared with 2.0 per cent for wettable sulphur.[2] The following year this material was formulated by the manufacturer at a concentration of 1 : 20,000 and this proved unsatisfactory in scab control.[3] As a result Puratized was tested at two concentrations in 1946 and 1947. When used at a concentration of 1 : 8000, the scab control was better than when used at 1 :16,000, but the difference did not warrant the additional cost. Fruit scab at either concentration was less than 1 per cent,

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[2] Folsom, D. Scab control. Bulletin 438, Maine Agricultural Experiment Station, Report of Progress for 1944-45, p. 645, 1945.

[3] ———— Apple spraying with new fungicides. Bulletin 442, Maine Agricultural Experiment Station, Report of Progress for year ending June 30, 1946, pp. 273-274. 1946.

while with wettable sulphur it was almost 2 per cent. A concentration of 1:16,000 means one pint of Puratized Agricultural Spray (1947 product) to 100 gallons of water.

While this experimentation was being conducted, Puratized was being used in several commercial orchards with varying results. In general the growers who used Puratized as a protectant did not obtain satisfactory control of scab, while, in most cases, growers who used the material as an eradicant spray were well pleased with the results. The factors responsible for this erratic performance are not clearly understood. Undoubtedly weather conditions both during and after the application, as well as the method of application, are important sources of variation. Other factors such as the vigor of the tree, the amount of scab carry-over, the kind of water used to mix the spray, and other possible influences not yet known may be responsible. In the experimental spraying at Highmoor Farm, Puratized has made an excellent showing both as a protectant and as an eradicant. It appears, however, that in commercial orchards, each grower has to learn how to use this material to best advantage under his own particular set of conditions. This is apparently especially true when Puratized is used solely as a protectant. A grower would do well to experiment some with Puratized, because this material is the only one of the new organic fungicides to show any promise as an eradicant. Properly used, it can replace lime sulphur in this respect, and will "burn out" scab without causing the foliage injury that accompanies the use of lime sulphur. Orchards were visited in 1947, where leaf scab was severe; somewhat more than 60 per cent of the leaves being infected in some cases. A spray of lime sulphur on such trees would have resulted in almost complete defoliation, thus interfering greatly with fruit bud formation for the following year. Puratized almost completely eradicated scab under these conditions, without any visible foliage injury from the fungicide. In addition to this advantage, Puratized is perhaps the easiest spray material to mix, since it is packaged in pint containers, and the liquid from one container is simply poured into 100 gallons of water. The disadvantages as far as now known are, in addition to the erratic behavior under commercial orchard conditions, questionable compatibility with lime and with some types of spray water being used in Maine. In the University

orchard at Orono, Puratized has been observed to cause severe defoliation when applied on Dolgo Crab trees. Although this variety is not commercially important, it may be well to exercise caution when spraying some of the miscellaneous varieties that occur in many orchards.

PURATIZED 806

This is a new formulation containing as the active ingredient, phenyl mercury formamide, and was used experimentally in Maine in 1947. The control of fruit scab was about equal to that obtained with Puratized Agricultural Spray.

Recommendations. Puratized Agricultural Spray should be tried by more growers, particularly as an eradicant spray. Because of the erratic performance of this material when used in commercial orchards as a protectant, it would be well for each experimentally minded grower to try this material under his own particular set of conditions and see if he can use it advantageously. In the experimental spraying program it has been one of the best of the materials tried.

FERMATE

This material has gained a place in the general spray program. It is the best fungicide known for the control of cedar-apple rust and quince rust. Fermate when used on russet susceptible varieties will greatly reduce this defect. Blocks of Red Delicious and Baldwin visited in 1946 and 1947 that were sprayed with Fermate were remarkably free from the russeting that had blemished the fruit when wettable sulphur was used. Fermate when used alone is about the equal of wettable sulphur in scab control. The active ingredient, ferric dimethyl dithiocarbamate, is formulated so that the usual dosage is 1.5 to 2.0 pounds Fermate to 100 gallons of water. When combined at the rate of ¾ pound Fermate and 4 to 5 pounds wettable sulphur, the combination seems to be more efficient in scab control than when either ingredient is used at full strength alone. Fermate has the disadvantages of being difficult to mix as a spray, usually requiring a separate operation to get the material into solution before adding it to the spray tank. It is incompatible with lime and questionably compatible with DDT. The kind of wetting agent used in formulating the DDT seems to

make a difference. When Fermate is used late in the season a dark colored residue may be evident on the fruit, which is particularly objectionable on yellow colored varieties. A dust may be prepared by mixing 10 per cent Fermate and 90 per cent talc (or other suitable carrier) if the material is to be used alone. In combination with sulphur as a 5 per cent Fermate-95 per cent sulphur dust the mixture seems to give better scab control than sulphur dust used alone. Lead arsenate may be added to either the spray or dust mixture.

Recommendations. If either cedar-apple rust or quince rust is a problem, Fermate should prove effective in control. If sulphur russeting is a problem, it would be well to try Fermate. Experimentally minded growers may also want to try a Fermate-sulphur combination either as a dust or a spray for scab control.

PHYGON

This material has been gaining in importance as an apple spray for several years. In the 1947 tests at Highmoor Farm, it was the best of 10 materials tried for scab control. Phygon was used in at least one commercial orchard in southwestern Maine in 1947 and the grower was well pleased with the results. The active ingredient, 2,3-dichloro-1,4-naphthoquinone, has been formulated differently in some years, and in the 1947 formulation at least, did prove somewhat harmful to the exposed skin of men operating the spray machinery. A skin irritation resulted which fortunately did not prove to be serious. There are an increasing number of reports that this material will reduce the size of fruit and will cause spray injury to foliage. A mottling of the foliage has been reported in several other New England States when Phygon was used. There are also at least 2 reports of rather severe injury when either DN 111 or D 4 was applied to foliage previously sprayed with Phygon, even when there was an interval of over 1 month between the Phygon and the DN applications. No spray injury of any kind was apparent in Maine during the 1947 season, but tests were not made on the effect of DN materials on Phygon-sprayed trees. Phygon is compatible with DDT and lead arsenate.

Recommendations. Because of the injury to the skin of spray operators and the injury to foliage and fruit reported from

other states, it would seem best to consider Phygon as still an experimental material in Maine orchards. If growers wish to try it, the manufacturer's recommendation of ¾ pound to 100 gallons should not be exceeded. It may be well to try Phygon at the rate of ½ pound to 100 gallons.

COPPER 8-QUINOLINOLATE

This is one of the newer materials and, on the basis of 1947 tests, appears very promising. It is an organic compound containing copper and apparently can be sprayed on apple foliage without any of the ill effects that usually accompany copper applications. Since this material contains copper it may cause fruit russet under certain conditions. The control of fruit scab that was obtained in 1947 was about equal to that obtained with wettable sulphur and experience elsewhere indicates that this material may be an excellent fungicide. It is compatible with lime, lead arsenate, oil stickers, and DDT, but is not compatible with nicotine.

Recommendations. Until more data are available it is best to consider copper 8-quinolinolate as experimental.

EXPERIMENTAL FUNGICIDE 341 (THE GLYOXALIDINES)

This material has been tried in Maine for the past 3 years and shows some promise. Difficulties in formulation have resulted in several different products being tried, and a liquid formulation seems best. It is necessary to add a small quantity of lime to the spray mixture in order to liberate the toxic ingredient. Trials at Highmoor Farm in 1947 showed this liquid formulation to be sixth in a list of 10 materials tried for scab control, but the indications are that further research on formulation should provide a better material. It is not a material to ignore and further tests will be conducted.

Recommendations. Experimental Fungicide 341 should be considered strictly as experimental at the present time.

POLYETHYLENE POLYSULFIDE (GOOD-RITE)

This material was tried in Maine in 1947 and when used as a fungicide alone showed little promise in scab control, being the poorest of the 10 materials tried. There are indications that this

material may prove to be useful as a sticker for other fungicides and insecticides.

Recommendations. This material should not be considered for use in the Maine apple spray program at the present time.

APPLE SCAB CONTROL

Producing apple crops free from scab has been made more difficult recently by a series of "bad scab years" characterized by rainy weather early in the growing season and combined with a heavy scab carry-over. Even under these adverse conditions some growers did harvest clean crops of fruit. The writers during these years made a series of surveys in a number of representative commercial orchards, observing the general spray program and the degree of disease and insect control obtained. Thoroughness of coverage and timeliness of application seemed to be most important in scab control. The sort of fungicide, the number of applications, and the kind of equipment used did not appear to be determining factors, so long as the trees were thoroughly covered at the proper times. Good control under adverse conditions was more difficult when only dust was used, but some growers produced clean crops with only 1 or 2 sprays supplementing a regular dust program.

For some years now, the various agencies responsible for writing the annual spray and dust schedule have been listing a standard schedule for scab control consisting of a prepink, pink, petal-fall, and 3 or 4 cover applications. Many growers have found that they obtained satisfactory control in some years when the specified number of applications was reduced. Some make a practice of making the first application about midway between the prepink and pink stages and then waiting until petal fall before making the second application. In years when scab is not serious, a schedule such as this probably will give satisfactory control in many orchards. In a rainy season, when scab infection is becoming severe, more applications are needed, the number depending upon the frequency of the rain and the amount of unprotected foliage. The best scab control occurred where at least 3 applications of a fungicide were made before petal fall. For those relying strictly on a dust schedule 4 or 5 applications were needed before petal fall, and

in a very rainy season better control resulted when 1 or 2 sprays supplemented the dust schedule.

One practice of some growers in determining the number of applications seems to be particularly undesirable. It has become common for some to spray or dust from the windward side of the trees early in the morning, quitting when the wind becomes troublesome and then waiting several days for the wind to shift or subside before dusting or spraying the other side of the trees. This seems to be based on the assumption that an application of a fungicide from only 1 side was all that was required for protection at the time. If asked how many times he applied a fungicide such a grower will almost invariably consider the 2 applications separate and complete. Actually they constitute only 1 and that 1 is not entirely effective. It is right and proper to stop operations when the wind becomes troublesome, but spraying or dusting should be resumed as soon as weather conditions favor good coverage, and both sides of the trees should be thoroughly treated as the work progresses. In years of light scab infection, dusting or spraying from only 1 side of a tree may prove satisfactory, but in general, for good scab control, coverage is very important, and a tree is protected best when a fungicide application is made immediately from both sides. Moreover, spraying first from 1 side and then from the other side a day or 2 later is likely to increase spray injury.

Recommendations. In some years scab is a comparatively minor problem, particularly when there is little spring rain, with a light carry-over of infection. Under these conditions only 2 applications of a fungicide may be required early in the season, the first application about midway between prepink and pink, and the second at the time of petal fall. In most years the standard schedule of prepink, pink, and petal fall is more reliable. In years when weather conditions favor scab infection, the number of applications will depend upon the frequency and intensity of rain. One particularly dangerous period is during bloom. A mid-bloom application of a fungicide, without lead arsenate or DDT, will many times make the difference between good scab control and a troublesome infection. At all times the grower should be guided by the development of unprotected foliage and the weather conditions. Even when weather conditions do not appear favorable

for scab development, new foliage, especially early in the season, generally should not be left without fungicidal treatment longer than 7 to 10 days. Scab control is dependent upon the foliage being protected with a fungicide during periods when infection is possible. Fig. 3 shows the time interval for various temperatures during which wettable sulphur should be applied for preventing scab infection.

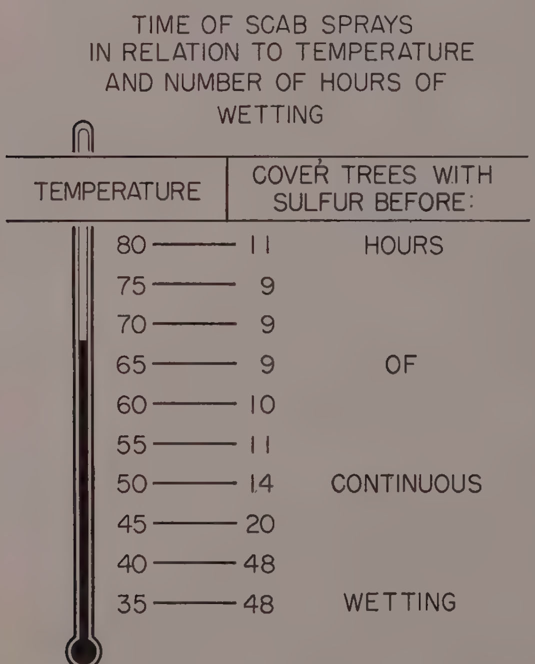

FIG. 3. Time intervals for various temperatures during which wettable sulphur should be applied for preventing scab infection.

OYSTER-SHELL SCALE CONTROL

During the past few years, considerable progress has been made toward the successful control of oyster-shell scale in Maine

apple orchards. To be successful, any treatment applied should be based upon a knowledge of the seasonal cycles of the scales.

Through the winter months, the oyster-shell scale remains alive in the form of eggs safely protected under the old scale covers. A single scale cover may contain from 25 to 150 or more eggs. The eggs begin to hatch in the spring between petal fall and the first cover application. Hatching may continue through a period of 2 to 4 weeks, depending upon weather conditions. The hatching eggs produce exceedingly minute, light-colored "crawlers." After a few hours of movement, the crawler settles down, inserts its beak into the apple bark, and begins the formation of a scale cover. After it settles down, the scale insect never moves again, but lives and grows through the summer by sucking nourishment from the apple tissues. It is the multitude of living, growing insects, each under its protecting scale cover, during the summer months, that cause severe injury to the trees. By late summer, the insects reach full growth. During the fall, eggs are produced under the scale covers, and the mother scale insects die.

There are 2 periods during the year when insecticides may be used successfully to combat the oyster-shell scale. (1) During the dormant period, when comparatively concentrated insecticides can be used without excessive injury to the trees. (2) During the hatching period, when comparatively mild insecticides can be used to destroy the "crawlers" before they form their protective scales.

Experiments conducted in 1945 and 1946 showed the value of the dinitro sprays during the dormant period. In comparison with the dinitro sprays, oil emulsion and liquid lime sulphur at dormant strength were of little or no value for scale control.

The thorough application of 1 gallon of liquid dinitro (Elgetol) in 100 gallons of water applied in the early spring reduced the scale population by about 96 per cent. Increasing the dosage to 2 gallons of dinitro in 100 gallons of water did not greatly increase the effectiveness of the spray, but reducing the dosage to ½ gallon materially reduced the value of the spray. Complete and thorough coverage of each tree—trunk, limbs, branches, and twigs—is essential for scale control. Poor coverage means failure.

When applied in the late fall, the dinitro spray was about 10 or 15 per cent less effective than the spring application. The

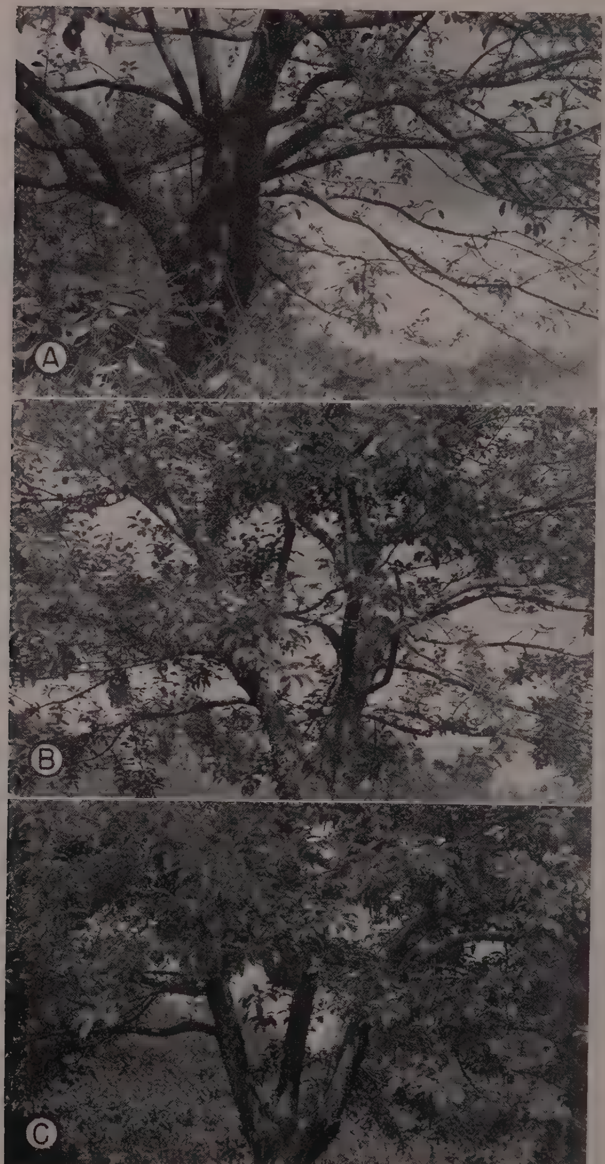
A
B
C

Fig. 4. A. McIntosh apple tree to which no treatment was applied for the control of oyster-shell scale. Notice the sparsity of foliage and the weakened branches.

B. McIntosh apple tree which was dusted with 5 per cent DDT-sulphur, in the petal fall, first, and second covers in 1947, but not in 1946. Notice the better foliage and more vigorous appearance of the tree as the result of one year's treatment for scale control.

C. McIntosh apple tree dusted for oyster-shell scale control in 1946 and again in 1947. Notice that after 2 years of scale control the tree is returning to a normal state of health.

The three photographs were taken in an experimental orchard at Monmouth, August 7, 1947.

fall spray was less effective, probably because the old leaves that hang on late in the fall make it difficult for the spray to reach and cover all of the scale infested twigs and branches.

Because of the expense and difficulty encountered in making dormant spray applications, it would be valuable to the apple grower to have an effective summer treatment for oyster-shell scale. The new insecticide, DDT, seemed to have qualities that would make it valuable as a summer treatment for scale. Preliminary tests with DDT were undertaken in 1945, and experiments have been continued in 1946 and in 1947.

Results of the experiments showed that when thoroughly applied, DDT is very effective for destroying the newly hatched crawler stage of the oyster-shell scale. By properly timing the applications, it was found that DDT thoroughly applied as liquid spray or as dust reduced the scale population by 85 to 95 per cent.

Trees that had been heavily infested and severely injured by oyster-shell scale showed marked improvement after being dusted with 5 per cent DDT-sulphur dust in 1946. After the second season of DDT dust applications in 1947, the dusted trees were approaching a normal state of health (Fig. 4). Trees that were not dusted with DDT suffered increasingly severe injury.

Recommendations. Dormant treatment. The thorough application of dinitro spray during the dormant season, preferably in the spring just before the apple buds show green tips, has proved to be an effective method of combating oyster-shell scale. Use 1 gallon of liquid dinitro (Elgetol) or 3 to 4 pounds of dry dinitro (Dinitro Dry) in 100 gallons of water.

Because of the apparently satisfactory control of oyster-shell scale by summer applications of DDT, it appears that the dormant application of dinitro spray, if it is used at all in the future, may become primarily a supplementary treatment. It is suggested that the dinitro spray can be applied efficiently to the trunk, limbs, and large branches. The small branches and twigs can perhaps be treated more efficiently by summer applications of DDT.

Summer treatment. For the effective control of oyster-shell scale by summer applications of DDT, thorough application and proper timing are essential. In spraying or dusting, special effort should be made to thoroughly cover every part of the tree—trunk, limbs, branches, and twigs. In timing the treatments, the idea is to make the first application just before the newly hatched crawlers appear, the second application is made just before the peak of hatching. Because dust usually weathers off more rapidly than liquid spray, a third application of dust is recommended shortly after the peak of hatching. Because the time of hatching of the crawlers varies from year to year, depending upon weather conditions, the most effective timing probably should be determined each year by observations of the hatching scales. The timing of the applications recommended here is believed to represent a workable average. Perhaps further experimentation will develop improved timing, and greater efficiency of control.

As a liquid spray, make 2 applications of 3 pounds of DDT 50 per cent, wettable powder, plus the usual quantity of wettable sulphur in 100 gallons of water.

Where dust is used, make 3 applications of DDT 5 per cent mixed with sulphur dust (Kolodust Niatox 5).

The first application should be made at late petal fall; the second application 5 to 7 days after the first; and where dust is used a third application should be made 5 to 7 days after the second.

DDT is not very effective against plum curculio. Where this pest is a problem, lead arsenate should be included in the petal-fall and first cover applications. DDT and lead arsenate are compatible and may be used together in spray or dust. Do not combine DDT with lime-sulphur or with lime.

LEAF HOPPER CONTROL

There are 2 species of leaf hoppers that frequently are injurious to apple trees in Maine; the white apple leaf hopper (*Typhlocyba pomaria*) and the potato leaf hopper (*Empoasca fabae*).

The white apple leaf hopper occurs most abundantly in mature trees, where it concentrates its attack upon the mature foliage. The first indication of attack is a fine stippling of minute whitened spots on the upper surface of the leaves. As the injury progresses, the spots become more numerous until the leaves become pale in color, and in late summer the entire tree may take on a sickly color somewhat resembling European red mite injury. Severe leaf hopper injury may weaken the tree, and reduce the size of the apples. During dry weather the leaves and fruit may become soiled by the excreta from the hoppers. This dark, unsightly discoloration usually is washed away by rain before picking time.

The white apple leaf hopper spends the winter as eggs inserted just under the apple bark, mostly on 1- or 2-year growth. The eggs begin hatching about the time of petal fall. The newly hatched hoppers are very small, light colored, wingless nymphs that crawl actively and live and feed on the undersides of the apple leaves. The hoppers of the first brood become full grown and develop wings late in July. Eggs are laid in the veins on the underside of the apple leaves, and the young hoppers of the second brood begin to appear during mid-August. Before picking time, hordes of the winged hoppers of the second brood swarm in the infested trees.

The green, potato leaf hopper attacks young apple trees, or the terminal shoots of mature trees. It is especially injurious to nursery trees, and only occasionally becomes numerous enough to cause important injury to mature trees in Maine. The potato leaf hopper causes a rolling or cupping of the leaves of the terminal shoots. On nursery trees, the attacks force out excessive growth of lateral branches, and in extreme cases the young trees may be severely injured.

The potato leaf hopper probably does not overwinter in Maine, but the adult hoppers fly in from the south each spring. The hoppers appear in apple trees during the last week in June or the first week in July. Eggs are laid in the apple tissues, and

the tiny, young hoppers soon appear. A second generation of potato leaf hoppers develops in August.

During past years special applications of nicotine sulphate (Black Leaf 40) as liquid spray or as dust were recommended for the control of leaf hoppers on apple trees. Nicotine sulphate is expensive, however, and the treatments often were disappointing. DDT has proved to be an economical and effective insecticide for combating leaf hoppers on apple trees.

Recommendations. For the control of the white apple leaf hopper DDT should be used either in the petal fall or in the first cover application to destroy the young hoppers of the first brood. Where the first brood has been reduced thoroughly, there usually will be no important injury from the second brood. If the first brood has not been destroyed, DDT may be applied for the second brood late in July. Late applications are more likely to produce excessive residue on the harvested fruit, however, and it is better to apply treatment for the first brood. DDT applied as recommended for combating the oyster-shell scale will control the white apple leaf hopper.

Watch should be kept of apple trees in the nursery during late June and early July. DDT should be applied as soon as the potato leaf hoppers first appear. The treatment should be repeated if the hoppers reappear.

For liquid spray use 3 pounds of 50 per cent wettable DDT plus the usual amount of wettable sulphur for scab control. If dust is applied, use 5 per cent DDT-sulphur dust.

EUROPEAN RED MITE CONTROL

The European red mite winters over as minute, bright red eggs on the bark of the apple branches and twigs. The eggs hatch in the spring, about the time the apple blossoms are in the "pink" stage. The mites feed and multiply on the apple leaves throughout the summer. The last eggs laid in the fall remain overwinter to hatch next spring. Generally the infestation of red mites in Maine orchards is at a low ebb in the early spring. Infestation may build up so rapidly that severe injury may be threatened as early as 2 weeks after petal fall. In most orchards, however, the heaviest

infestation, with greatest injury, is likely to occur during late July and in August.

Destructive attacks of European red mite have increased in frequency and in severity in Maine apple orchards during the past 6 or 8 years. This increase in mite injury has been noticeably parallel to the increased use of wettable sulphur and sulphur dust for the control of scab. It seems probable that the condition has arisen because sulphur fungicides are destructive to the natural enemies of the mites, but have comparatively little effect upon the European red mite. The use of mild forms of sulphur has necessitated increased numbers of applications with greater thoroughness of coverage for scab control than were necessary when lime-sulphur was commonly used. All this apparently has made conditions favorable for the development of European red mite. The outbreak of oyster-shell scale in many Maine orchards during recent years probably also has been induced to a considerable degree by the same conditions that promote the increase of European red mite.

It seems possible that some fungicide might be developed that would not promote the development of the European red mite, and as rapidly as practicable, the new fungicides will be tested in this respect. In 1947, experimental Fungicide 341 was applied to a block of McIntosh in a commercial orchard in western Maine, and an adjoining block of McIntosh was sprayed with wettable sulphur. All sprays were applied by the usual spray crew under the direction of the orchardist, the timing and method of application were the same for both blocks. A noticeable difference in red mite population developed in the 2 blocks. About midseason it was necessary to apply a special red mite spray on the wettable sulphur block, while mites were practically absent from the block spray with the Fungicide 341. As the fruit began to increase in size, a second application became necessary in the wettable sulphur block. Later in the season it also became necessary to spray for red mite in the block treated with Fungicide 341. This was only a preliminary test, and the results are not conclusive. The effects upon European red mite control, however, were sufficiently promising to warrant further tests along this line. Oyster-shell scale was not a problem in this orchard, and no data were obtained on this insect.

For a number of years the only recommended treatment for European red mite in Maine orchards was the application of an oil spray in the delayed dormant period for the destruction of the over-wintered eggs. During the period prior to the greatly increased use of the mild sulphurs, one thorough application of oil spray generally subdued European red mites for a period of 4 or 5 years, and summer treatments for mite control usually were not considered necessary. In recent years, however, the increasing severity of red mite attacks made summer treatments imperative. The DN compounds, DN 111 spray and D 4 dust, were developed for the summer treatment of European red mite, and have proved reasonably safe and effective, but burning of the foliage has resulted where the application was made when the temperature was too high. The DN compounds are more effective against the mites than against the eggs, but there is considerable residual effect, and many mites that hatch within 2 or 3 days after treatment, will be killed. Under certain conditions the DN spray and dust applications have been observed to "burn out" scab infections, but are not recommended for scab control. Still more recently, a number of promising new materials (hexaethyl tetraphosphate, hexaethyl pyrophosphate, and parathion[4]) are beginning to emerge from the purely experimental stage, and show considerable promise.

Recommendations. Where severe European red mite injury has been persistent, an oil spray thoroughly applied in the delayed dormant period, will reduce the infestation and may make summer treatment unnecessary for that season. Oil emulsion or miscible oil may be used, and generally is diluted to give about 3 per cent of oil in the spray. In using oil, however, the manufacturer's directions should be followed carefully.

For summer treatment, DN 111 spray or D 4 dust is recommended. The treatment should be applied as soon as red mites threaten to be injurious, and before severe injury occurs. Two or more applications may be necessary to keep the mites under control through the season where infestation is severe. These materials should not be applied to apple trees sooner than 2 to 4 weeks after petal fall, and applications should not be made when the temperature is 80° F. or higher.

[4] Parathion is the common name designating the chemical, 0,0-diethyl 0-p-nitrophenyl thiophosphate.

In the experimental tests hexaethyl tetraphosphate and pyrophosphate were very rapid in action and killed a high percentage of the mites, but were not very effective against the eggs. This material is prepared only in the liquid form.

Parathion apparently was about as effective as hexaethyl tetraphosphate or pyrophosphate. Parathion has considerably more residual effect, and also has the advantage of being suitable for either liquid or dust applications.

Growers who are experimentally inclined may wish to try hexaethyl tetraphosphate, pyrophosphate, and parathion. Although these new materials appear to be quite safe for use on apple trees, they are very poisonous to humans and to domestic animals. The spray crew should observe caution in handling and applying such materials, and the directions should be followed exactly.

APPLE FRUIT FLY CONTROL

Although there have been no revolutionary changes in the methods recommended for the control of the apple fruit fly, there have been some new developments during recent years that have been helpful in the fight against fruit fly infestation in Maine orchards.

Fig. 5. A. Severe fruit-fly injury in an advanced stage. F. Female apple fruit fly. E. Shows a newly deposited egg under the skin of the apple, and next to it an egg that has recently hatched. The arrow points to the eggs as they appear in the apple. L. Full grown larva ready to leave the apple. P. Puparium within which the resting stage of the insect spends the winter in the soil.

The apple fruit fly spends the winter in the resting stage a few inches beneath the surface of the soil (Fig. 5). The flies usually begin to emerge from the soil during the last week in June (25 to 30 days after McIntosh petal fall), and the peak of emergence occurs near the middle of July (45 to 50 days after McIntosh petal fall). After a developmental period of 7 to 10 days following emergence, the flies begin to lay eggs just under the skin of the apples. The eggs hatch into small larvae that feed within the apples. As the apples near the ripening stage, the larvae develop rapidly. When the larvae become full grown they

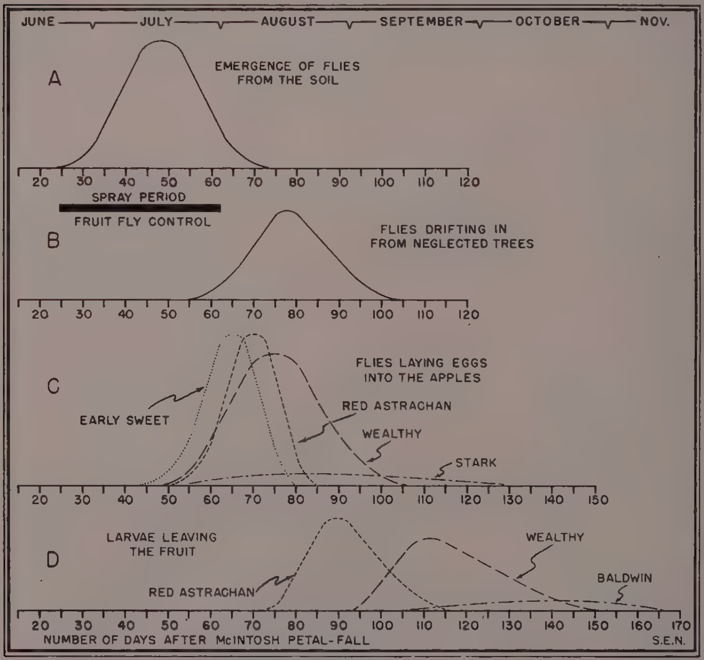

FIG. 6. Seasonal cycles of the apple fruit fly. The number of days after McIntosh petal fall is shown under each section. The average calendar dates at Highmoor Farm are shown at the top of the chart. The calendar dates vary in different localities, but the time with respect to McIntosh petal fall holds reasonably constant throughout the apple-growing sections of Maine.

drop to the soil where they remain over winter. The seasonal cycles are clearly shown in Fig. 6.

During recent years it has become increasingly evident that the drifting flies that come in from neglected orchards present a difficult problem to the commercial orchardist. This is especially true where the orchard is in a community having many neglected apple trees that have built up a general and severe fruit fly infestation. Most of the drifting flies are ready to lay eggs when they enter the orchard, and many apples may be stung before the insecticide deposit on the trees can kill the incoming flies. The importance of drifting flies was shown most convincingly in the summer of 1945. Because of adverse weather conditions during the early spring, the apple crop was very light, and many orchards bore practically no apples in 1945. Normal numbers of flies emerged from the soil, however, and many of the flies that emerged where there was no fruit, drifted into the relatively few orchards that bore fruit. In spite of sprays applied for fruit fly control, the infestation in 1945 was the heaviest that has occurred in Maine commercial orchards during recent years.

In the orchard where drifting flies are an important problem, the application of lead arsenate should be continued through July. In some orchards improved control might be obtained if the lead arsenate applications could be extended into August. Because of the danger of excessive spray residue on the fruit, however, the application of lead arsenate during August is generally considered inadvisable.

For the reason that DDT appears to be somewhat more rapid in its action than lead arsenate, it may be of value for combating the drifting flies. In tests in a heavily infested Wolf River orchard at Monmouth during the past few years, 3 applications of 5 per cent DDT dust during July, reduced the number of egg punctures in the fruit by as much as 80 per cent. In the 1947 experimental plots where 1 DDT liquid spray (3 pounds of 50 per cent DDT wettable) or 2 DDT dusts (5 per cent DDT) were applied for fruit fly control late in July, chemical analyses of samples of the apples showed that the residue on the fruit at picking time did not exceed 0.61 part per million—which, according to present information, is well below any quantity that would be considered injurious to human health.

In an experimental McIntosh orchard in Monmouth, where drifting flies were an important problem, a schedule of 2 applications of 75:25, sulphur-lead arsenate dust during the first half of July, followed by 2 applications of 5 per cent DDT in 85:15, sulphur-lead arsenate dust during the last half of July, gave the best control of fruit fly that has been obtained in the test orchard in recent years.

In timing the applications for fruit fly control, the general recommendation has been to make the first application of lead arsenate spray soon after the flies begin to appear in observation cages set out for that purpose. A second spray application is generally recommended at about the peak of emergence of the flies. When dust is used, 3 applications are generally recommended. Under approximately normal conditions, such a schedule proved satisfactory. It sometimes happens, however, that such timing does not fit well into the schedule followed by the grower. Rains may remove the spray deposit prematurely, while during dry periods the protective period of the application may be prolonged. It seems that a more satisfactory recommendation might be to maintain a protective deposit of lead arsenate on the trees from the time that the flies begin to emerge, to the end of the spray season.

During the recent years some growers have considered the advisability of delaying the first fruit fly application until flies have been observed in the apple trees, rather than making the first application when flies begin to appear in the observation cages. In some orchards such timing may be satisfactory, but it too often happens that flies are not observed in the trees until after many of the apples have been stung, when it is too late for the treatment to be fully effective.

Recommendations. A protective deposit of lead arsenate should be maintained on the trees from the time the flies begin to emerge from the soil, until the end of the spray season. Under approximately normal conditions, 2 liquid sprays (3 pounds of lead arsenate per 100 gallons) or 3 dusts 85:15 sulphur-lead arsenate should be sufficient in the commercial orchard. Where infestation is severe, or where drifting flies are a problem, and especially during seasons of frequent, heavy rains, it may be necessary to increase the number of applications in order to main-

tain the protective deposit on the trees. It also may be advisable to use 75:25 sulphur-lead arsenate dust instead of 85:15.

Spraying or dusting bushy fence rows and low trees or bushes in or near the orchard is advisable because such places may harbor many of the fruit flies, especially before the flies begin laying eggs.

To combat the drifting flies, it is important to clean up the infestation in the locality of the orchard as completely as practicable. Neglected apple trees should be removed or sprayed, and the dropped apples from infested trees should be collected and destroyed.

Some growers may wish to try DDT applications, especially where drifting flies are a problem. One liquid spray (3 pounds of 50 per cent DDT wettable, plus the usual amount of wettable sulphur, in 100 gallons of water) or 2 dust applications (5 per cent DDT in 85:15 sulphur-lead arsenate) during late July should help to combat the drifting flies. The usual lead arsenate applications should be made during the first half of the fruit fly control period.

Caution should be observed to avoid excessive applications of DDT or of lead arsenate, especially in the late applications. It is recommended that DDT applications for fruit fly control should be limited to comparatively small trial blocks where fruit fly control has been difficult, until the effects can be more fully understood.

SPRAY DEPOSITS ON APPLE FOLIAGE[5]

For several years research has been conducted on McIntosh trees at Monmouth on the deposition and retention of lead arsenate when applied as a dust. This work was expanded in 1946 to include sulphur and the relative behavior of both sulphur and lead arsenate when applied as a dust and as a spray. Although the data obtained are not sufficient for making final and conclusive statements some information of interest and value has been gained.

To facilitate comparisons of the data from the several plots in different orchards, the height and branch spread of each tree

[5] Lathrop, Frank H., Merle T. Hilborn, Bernie E. Plummer, Jr., and A. Stanley Getchell. Spray deposits on apple foliage. Maine Agr. Expt. Sta. Bul. 449. Report of Progress for Year Ending June 30, 1947, pp. 406-411. 1947.

was measured and the volume computed. A tree unit of 4200 cubic feet was then used as a standard, because this was the volume of a typical, mature, bearing McIntosh tree in Maine.

The individual applications of both dust and spray showed considerable variation in the deposits of arsenic and of sulphur in relation to the quantity of lead arsenate and sulphur applied to the tree. This variation in deposit was apparently influenced by a number of factors acting at the time of the application, such as air currents, the amount of moisture on the foliage, the character of the foliage, and the ability of the man making the application. The relative value of these factors must await further research.

In general it was found that the quantity of arsenic and of sulphur deposited on the apple foliage was dependent upon the quantity of lead arsenate and of sulphur used in making the applications. Liquid spray was more efficient in the use of material than was dust, as measured by the quantity of arsenic deposited by a given quantity of lead arsenate. For example, a liquid spray containing 3 pounds of lead arsenate and 10 pounds of wettable sulphur per 100 gallons, applied at the rate of 7 gallons per tree unit, deposited on the average, more than 3 times as much arsenic as did the same quantity of lead arsenate applied as an 85:15 sulphur-lead arsenate dust.

One of the primary objects of the 1946 experimentation was to determine and compare the quantities of sulphur and lead arsenate deposited by:

(1) A "standard"[6] application of a "standard"[6] spray formula
(2) Double the gallonage of the same formula
(3) The "standard" application of spray containing double the quantity of sulphur and of lead arsenate

The quantity of sulphur deposited by the "standard" spray applied at the rate of 7 gallons per tree unit was determined and used as a basis for comparison. When the quantity of wettable sulphur in the spray was doubled (increased from 10 pounds to 20 pounds in 100 gallons of water) and applied at the standard rate

[6] The application of 7 gallons of liquid spray per tree unit was considered a "standard" application, and the "standard" formula consisted of 10 pounds of wettable sulphur and 3 pounds of lead arsenate in 100 gallons of water.

(7 gallons per tree unit) the resulting deposit of sulphur on the foliage was not doubled, but was increased about 57 per cent, Fig. 7. When the "standard" formula (10 pounds of wettable sulphur in 100 gallons of water) was used at double the rate of application (14 gallons per tree unit) the deposit of sulphur was increased only about 40 per cent, as compared with the application of 7 gallons per tree unit. The deposit of lead arsenate follows the same general principle as does the deposit of sulphur, Fig. 8.

It is evident that a desired increase of sulphur can be deposited more economically by increasing the concentration of the spray material, rather than by increasing the amount of spray applied

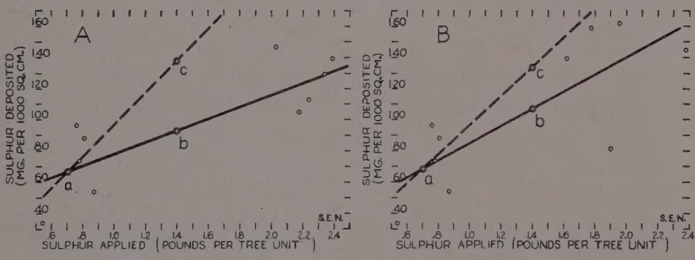

FIG. 7. The deposit of sulphur on apple foliage, in relation to the quantity of wettable sulphur applied in liquid sprays. On A and B, line *a-b* is the regression line, and may be considered as indicating the average amount of sulphur that was deposited by the application of given quantities of wettable sulphur.

A shows the increased deposit of sulphur that resulted from increasing the number of gallons of spray applied per tree unit. Point *a* indicates the average amount of sulphur deposited by the application of 7 gallons per tree unit of a "standard" spray formula. Point *b* indicates the average amount of sulphur deposited by the application of 14 gallons of a "standard" spray formula. Point *c* indicates the amount of sulphur that would have been deposited if 14 gallons of spray had deposited twice as much as 7 gallons.

B shows the increased deposit of sulphur that resulted from increasing the quantity of wettable sulphur in the spray mixture. Point *a* indicates the average amount of sulphur deposited by the application of 7 gallons per tree unit of a "standard" spray formula. Point *b* indicates the average amount of sulphur deposited by the application of 7 gallons of double strength spray. Point *c* indicates the amount of sulphur that would have been deposited if double strength spray had deposited twice as much as a "standard" spray.

Notice that the efficiency of deposit decreased as the quantity of wettable sulphur applied was increased, but it appears somewhat more efficient to increase the quantity of sulphur in the spray rather than to increase the number of gallons of spray applied.

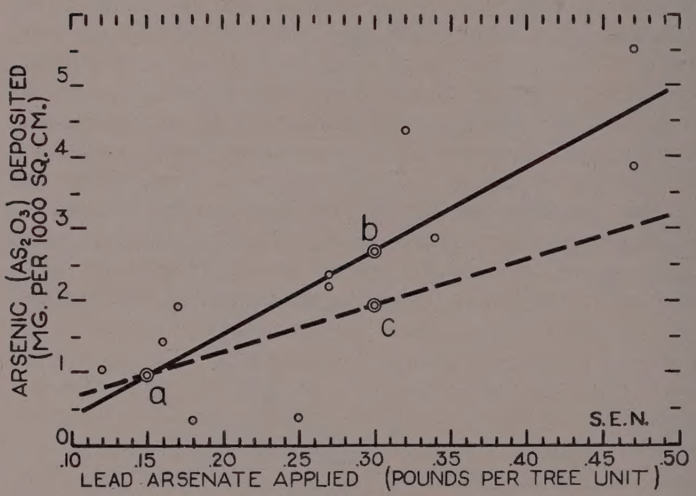

FIG. 8. The deposit of Arsenic (As_2O_3) on apple foliage, in relation to the quantity of lead arsenate dust applied per tree unit. The small circles represent data from individual applications of lead arsenate and sulphur dust. The line *a-b* is the regression line, and may be considered as indicating the average amount of arsenic that was deposited by the application of given quantities of lead arsenate. Point *a* indicates the average amount of arsenic deposited by the application of 1 pound of 85:15 sulphur-lead arsenate dust per tree unit. Point *b* indicates the average amount of arsenic deposited by the application of 2 pounds of the same dust per tree unit. Point *c* indicates the amount of arsenic that would have been on the leaves if 2 pounds of dust had deposited twice as much arsenic as 1 pound of dust. Notice that the efficiency of deposit increased as the quantity of dust applied per tree unit was increased.

to the trees. This does not necessarily suggest reducing the volume of spray applied, for regardless of the formula, it is necessary to apply sufficient spray to cover the trees adequately. The data do show, however, that more spray material is wasted when an excessive volume of spray is applied, than when the concentration of sulphur is increased.

The deposit of lead arsenate by dust application was found to behave somewhat differently than the deposit by liquid spray. When the quantity of dust applied was doubled (increased from 1 pound to 2 pounds of 85:15 dust per tree unit) the deposit of arsenic was more than doubled; giving an increase of 183 per cent.

Apparently this shows that the economy of dust deposits increases as the quantity of dust applied was increased from 1 pound to 2 pounds per tree unit. This should not be taken as an argument for wasting material by applying excessive amounts of dust. It does show that in dusting, when the amount of material applied is increased, there is a considerable increase in the economy of deposit on the foliage. In applying liquid spray, when the amount of material applied is increased, the economy of deposit is decreased.

Recommendations. In making summer applications, the grower should try to apply a volume of spray to each tree sufficient for thorough coverage, and excessive application should be avoided. Where this is done, spray containing 8 to 10 pounds of wettable sulphur and 3 pounds of lead arsenate in 100 gallons of water generally is sufficient for the control of scab and most insect pests. When it seems necessary to increase the deposit of sulphur or of lead arsenate, the quantity of the material in the spray should be increased, and the rate of application should remain just sufficient for the thorough coverage of the tree.